DOCUMENT RESUME

ED 313 826 EC 221 342

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TITLE Short-Term Memory of Children with Mental Retardation: Structural Defects or Control Deficits.
PUB DATE 87
NOTE 21p.
PUB TYPE Reports - Research/Technical (143)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS Auditory Stimuli; *Cognitive Processes; Comparative Analysis; Intermediate Grades; Junior High Schools; *Mental Retardation; Recall (Psychology); Recognition (Psychology); *Short Term Memory; Visual Stimuli
IDENTIFIERS *Memory Deficits

ABSTRACT

The short-term memory of 24 retarded and 24 nonretarded individuals, aged 10 to 14, under conditions of restricted cognitive strategy use was investigated. An attempt was made to determine whether short-term memory difficulties of persons with mental retardation are caused by deficits in voluntary cognitive strategies, such as the organization and verbal rehearsal of incoming information, or to untrainable structural processes. Three conditions were investigated: short-term visual recall of nouns, short-term auditory recall of consonant triads, and short-term visual recognition for unfamiliar designs in a match-to-sample format. Analyses suggested that both retarded and nonretarded subjects processed auditory and visual information in similar ways. However, subjects with mental retardation demonstrated less efficient information processing, faster than normal stimulus decay, and greater stimulus interference on both recall and recognition items under conditions of restricted cognitive strategies. These findings were interpreted as evidence for structural short-term memory defects of subjects with mental retardation. (Author/JDD)

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Short-Term Memory of Children with Mental Retardation: Structural Defects or Control Deficits

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EC 231342

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Abstract

The short-term memory of retarded and nonretarded individuals under conditions of restricted cognitive strategy use was investigated in the present study. An attempt was made to determine whether short-term memory difficulties of persons with mental retardation are caused by deficits in voluntary cognitive strategies such as the organization and verbal rehearsal of incoming information or to untrainable structural processes. Analyses suggested that both retarded and nonretarded subjects processed auditory and visual information in similar ways. However, subjects with mental retardation demonstrated less efficient information processing, faster than normal stimulus decay, and greater stimulus interference under conditions of restricted cognitive strategies. These findings were interpreted as evidence for structural short-term memory defects of subjects with mental retardation.

Short-Term Memory of Children with Mental Retardation: Structural Defects or Control Deficits

Investigations into the comparative abilities of retarded and nonretarded children in the areas of information processing and memory capability have been evolving since at least the nineteenth century (Galton, 1887; Jacobs, 1887). In recent years a controversy has been stimulated by the theoretical distinction between defect based structural differences and lack of volitional cognitive strategy control as possible explanations for variations in subject performance on experimental tasks requiring short-term memory.

The cognitive strategy deficit model postulates that development in children with mental retardation is similar to that of younger, nonretarded children. Failure to automatically and voluntarily use cognitive control strategies such as organization and chunking of incoming information, and the use of verbal rehearsal have been implicated as important in the inferior performance of subjects with mental retardation (Borkowski & Cavenaugh, 1979; Bray; 1979; Butterfield & Belmont, 1977; Campione & Brown, 1977). Mentally retarded persons apply memory enhancing control strategies poorly or not at all. Therefore, incoming information is inadequately organized, codified, and processed, and thus is doomed to be lost.

Advocates of the structural defect model view the cognitive development of retarded children as substantially different from that of the nonretarded child. They postulate that the information processing system in those with mental retardation lack integrity and are structurally defective. These differences in information processing render

subjects with mental retardation unable to remember items even after relatively short periods of time (Ellis, Deacon, & Wooldridge, 1985; Ellis & Meador, 1985; Ellis & Wooldridge, 1985; and Clark & Detterman, 1981).

In an attempt to discern the cause or causes of short-term memory problems that subjects with mental retardation fall prey to, the Brown-Peterson paradigm has been employed in recent years (Ellis, Deacon, and Wooldridge, 1985; Ellis & Meador, 1985). This paradigm uses a subject distractor task (either auditory or visual) immediately following the presentation of a group of stimuli to be remembered. The distractor task remains in use until the request for retrieval of the stimuli takes place. Presumably this distractor task fully taxes the information processing system of the subject so that voluntary cognitive devices such as chunking, organization, and rehearsal strategies cannot be applied effectively to aid in recall or recognition. This interference with voluntary memory strategies during exposure to experimental stimuli theoretically equates deficient and proficient strategy users on tasks requiring short-term memory. If the nonretarded subjects perform significantly better than the retarded subjects under these conditions, the remaining differences in their performance can not be attributed to voluntary control strategies alone. Strength is added to the structural difference explanation for this phenomenon.

Method

Subjects

A total of 48 subjects participated in the present study. The 24 participants with mental retardation were randomly drawn from the rosters of students identified as Educable Mentally Handicapped from a large metropolitan school district. The criteria used for eligibility for placement in the program for EMH students were those recommended by the American Association on Mental Deficiency (Grossman, 1983). The retarded subjects had a mean CA of 11.97 years (range 10.4 to 14.3 years). The nonretarded subjects were randomly drawn from classes within the general education program. The nonretarded subjects has a mean CA of 12.05 years (range 10.0 to 14.5 years).

Stimuli

The subjects were presented with three different types of stimuli; pictures of common nouns, auditory consonants of the alphabet, and original designs in a match-to-sample format. Ninety-six trails per subject were divided over three 20 minute session; 32 trial were presented within each 20 minute session. There were 8 trials for each of 4 stimulus retention intervals (0-, 10-, 20-, and 30- seconds), 16 trials at each stimulus exposure time (16 trials at 3- seconds and 16 trials at 5- seconds) for each of the three treatment conditions.

For the first condition, short-term visual recall, the stimuli were 32 triads of black and white pictures of common nouns. The triads were arranged vertically on 35 mm slides. In the second condition, short-term

auditory recall of consonants, there were 32 consonant triads recorded on audio tape. The exact phonetic length of each consonant and the interval of time between the naming of each consonant was mechanically controlled so as to allow precisely a 3- or 5- second exposure time for each triad. The third condition measured short-term visual recognition for unfamiliar designs in a match-to-sample format. The stimuli consisted of four, horizontally placed black and white unfamiliar designs from which a single standard was to be selected. The standard was presented in isolation for either a 3- or 5- second exposure period.

The projected area of the lighted field of viewing was 32 X 21 cm. All pictures and designs were photographed with a 35 mm camera and mounted on glass slides. The slides were presented using a standard Kodak carousal projector with auto-focus. The visual distractor task was made up of a 110 X 220 mm matrix containing 11 rows and 25 columns with about 6 mm separating each of the single or double digits. The digits within the matrix were systematically alternated so that a double digit appeared in every fifth position.

Procedure

The subjects were tested individually in three separate 20 minute sessions in order to allow for each of the three treatment conditions to remain independent from the other. For each treatment condition the individual subject was brought to a small room and seated at a table about 1 m from the projection screen. Following a practice session with the appropriate stimulus and the intervening distractor task the subject was

presented with one of the treatment conditions. Each stimulus condition was presented for either 3- or 5- seconds, followed by one of four retention intervals of 0- (immediate request for recall or recognition of the given stimuli), 10-, 20-, or 30- seconds. At the conclusion of a retention interval, a bell was sounded and a blank slide was presented indicating an immediate request for recall or recognition of the stimulus item. For the 10-, 20- and 30- second retention intervals, the item was followed by the distractor task counting matrix slide. Following the distractor slide and the sounding of the bell the subject was placed under a limited hold procedure in which a 3- second period of time was allowed for the recall or recognition of the requested item.

For the distractor task the subjects were instructed to watch the screen and to name aloud every other digit or digit pair proceeding from left to right, beginning with the first number in the upper left hand corner. The subjects were told that it was important to remember the stimulus items as best they could, but to say aloud the numbers in the matrix as rapidly as possible; the numbers in the matrix were not to be remembered. Those subjects (10.0% with mental retardation) who could not read double digit numbers were instructed to read these numbers as single digits. Subjects who could not recognize single digit numbers were eliminated from the study. For the recall conditions partial credit could be earned for partial recall or stimuli recalled in inverted order. For the match-to-sample recognition condition a binary system of scoring was employed.

The validity of the distractor task was demonstrated through a procedure in which data collected prior to and during the experiment were compared. The mean number of digits read by retarded and nonretarded subjects under memory load and non-load conditions were calculated. The former was based on digit naming performance during the memory tasks and the latter was derived from pre and post experimental trials in which digits were named without presentation of experimental stimuli. The results of *t*-tests of mean differences between memory load and non-load conditions were calculated for both groups. The group with mental retardation yielded a *t*-ratio of 1.98 (df = 46), the nonretarded group yielded a *t*-ratio of 1.04 (df = 46). Both *t*-ratios indicate non-significant statistical differences at the .05 level of confidence.

The conclusion to be drawn from these analyses is that the digit counting distractor task theoretically interfered with voluntary cognitive control strategies as evidenced by the non-significant difference between memory load and non-load conditions for both groups. A significant difference for either group in mean digits named under the memory load condition would be expected if the subjects were to employ cognitive control memory mechanisms during the distractor task.

Results and Discussion

Table 1 illustrates the results of the experiment analyzed by use of the Statistical Analysis System (Ray, 1982). A 3 (Treatment Conditions: Nouns, Consonants, and Designs) X 2 (Subject Type: retarded subjects, non-retarded subjects) X 2 (Exposure times of 3- or 5- seconds) X 4 (Retention

times of 0-, 10-, 20-, or 30- seconds) design was employed. Data were analyzed by use of a four-way Analysis of Variance (ANOVA.) An alpha level of .05 was set as the criterion for the determination of statistically significant differences. Subsequent Tukey's Standardized Range Tests (Dunn & Clark, 1987) were used to determine where the differences existed within significant F ratios.

Insert Table 1 about here

As can be seen in Table 1, there were several significant main effects. Significant differences were found for the treatment conditions Nouns, Consonants, and Designs $F(2) = 240.49$, $p < .001$. Results of the Tukey's t-test for the treatment conditions revealed that student performance was clearly superior on the designs condition compared with the nouns and consonants conditions. Additionally, performance on the nouns condition was significantly superior to that of the consonants condition. It seems as though all subjects were able to recognize unfamiliar designs in a match-to-sample format more accurately than they were able to recall pictures of nouns or auditory consonants of the alphabet. This reflects the well known relative ease of recognition memory items as compared to recall memory items.

Statistically significant differences were found between retarded and nonretarded subjects $F(1) = 1140.45$, $p < .001$. Nonretarded subjects performed at significantly higher levels than retarded subjects on all

dependent measures. Main effect were also found for the stimuli exposure times of 3- and 5- seconds $F(1) = 78.89$, $p < .001$, and for the stimuli retention intervals of 0-, 10-, 20-, and 30- seconds $F(3) = 294.90$, $p < .001$. A 5- second period of exposure to the stimuli in all conditions were found to be significantly superior to a 3- second exposure interval for both subject types. These findings indicate that the longer the stimuli to be remembered were presented, the better able both groups were to recognize or recall them.

Stimuli retention times of 0-, 10-, 20-, and 30- seconds were statistically different. Consistently, all subjects performed at higher levels of accuracy the shorter the retention interval. An immediate request for information yielded higher levels of memory than 10-, 20-, and 30- seconds, respectively. A 10- second delay in the request for information yielded higher levels of memory than 10-, 20-, and 30- seconds, respectively. A 10- second delay in the request for information yielded higher levels of memory than 20- or 30- seconds. And finally, a 20- second delay in the request for information yielded higher levels of memory than 30- seconds of retention time. It is apparent that the longer the distractor task was employed during the retention interval the less able both groups were to recall and recognize stimulus items accurately. The consistency of these findings for both groups of subjects support the notion that the Brown-Peterson distractor task did in fact interfere with the use of cognitive control memory devices in those subjects who employed

them. If this was not the case, recall and recognition accuracy would have increased at longer retention intervals allowing for the utilization of memory enhancing cognitive strategies.

It can also be noted from Table 1, that F ratios for several interactions were significant at or beyond the .05 level of confidence. Tukey's t-Test was again employed to discern the direction of difference within the significant F ratios. In the interaction treatment conditions (nouns, consonants, designs) X subject type (retarded, nonretarded), nonretarded subjects performed significantly better than retarded subjects in favor of the treatment conditions, designs, nouns, and consonants, respectively ($F(2) = 11.54$, $p < .001$). The fact that both retarded and nonretarded subjects performed at higher accuracy levels for designs, nouns, and then consonant conditions indicates that the two groups of subjects responded in a similar manner to the various types of stimuli overall. In other words, both groups of subjects automatically encoded all three types of stimuli during the exposure intervals in essentially the same manner. However, after initial, automatic encoding had occurred, the nonretarded group processed the stimuli significantly more efficient as evidenced by stimulus recall and recognition measures.

For the interaction treatment conditions X exposure time for all subjects ($F(2) = 5.13$, $p < .01$), significant differences were found for length of exposure time in favor of 5- seconds, and in favor of the treatment conditions, designs, nouns, and consonants, respectively. Again, it is demonstrated by these results that both types of subjects are able to initally process information in a similar fashion, but at significantly

different accuracy levels. For the interaction, treatment conditions X retention times ($F(6) = 8.80$, $p < .001$), all subjects again performed significantly better on treatment conditions, designs, nouns, and consonants, respectively. In addition, all subjects performed at higher levels when stimuli was requested immediately after presentation than when there was a 10-, 20-, or 30- second delay.

Statistically significant differences were found between all subjects X exposure times of 3 and 5- seconds ($F(1) = 5.05$, $p < .05$). Both retarded and nonretarded subjects performed at significantly higher levels the longer the exposure interval. An exposure time of 5- seconds yielded higher levels of recall and recognition accuracy than a stimulus exposure time of 3- seconds for both retarded and nonretarded subjects. However, when the exposure time increased from 3- to 5- seconds the retarded subjects demonstrated a 27 percent increase in accuracy as compared to an 8.67 percent gain in accuracy for the nonretarded subjects over the same increase in stimulus exposure time. It would appear that for all subjects, the longer the stimulus exposure time, the more able they were to remember stimuli upon request. The retarded subjects seem to gain a remarkable and significant benefit from this increase in time over nonretarded subjects. Even though both types of subjects intially encoded information in a similar fashion, an increase in the amount of time allowed to perform this encoding benefited the subjects with mental retardation to a significantly greater degree. In fact, the nonretarded subjects were able to recall and recognize stimuli at significantly higher levels for a 3- second exposure time compared to the retarded subjects' performance at a 5- second exposure

time. It seems as though the nonretarded subjects are able to process information initially at significantly more efficient levels than the retarded subjects.

In the final significant interaction, subject type X retention time ($F(3) = 14.86$, $p < .001$), both retarded and nonretarded subjects performed significantly better when stimuli was requested immediately after presentation than when there was a 10-, 20-, or 30- second delay in recall or retention, respectively. Statistically significant differences were found between retention times of 0-, 10-, 20-, and 30- seconds for all subjects. Consistently, all subjects performed at higher levels of memory the shorter the retention interval. An immediate request for information yielded higher levels of memory than a request after delays of 10-, 20-, and 30- seconds, respectively. A 10- second delay in the request for information yielded higher levels of memory than 20- or 30- second delays. And finally, a 20- second delay in the request for information yielded higher levels of memory than 30- seconds of retention time. This occurred regardless of the treatment condition. It would appear that for all subjects, the longer the distractor task was employed, interferring with voluntary cognitive control strategies, the less able they were to remember stimuli upon request.

Both retarded and nonretarded subjects had similar performance patterns in the respect that the longer the retention interval, the more impaired their performance. Nonretarded subjects performed at significantly higher levels than the retarded subjects on all retention intervals, however. It is interesting to note that the retarded subjects

suffered more of a memory loss in comparison to the nonretarded subjects with an increase of retention intervals from 0- to 10- (a 31.5 percent loss for the retarded subjects compared to a 14.85 percent loss for the nonretarded subjects); from 10- to 20- seconds (32.01 percent for the retarded subjects compared to a 9.99 percent loss for the nonretarded subjects); and finally from 20- seconds to 30- seconds (a 23.99 percent loss for the retarded subjects and a 12.21 percent loss for the nonretarded subjects).

It is also interesting to note that even though both groups of subjects demonstrated deleterious effects the longer the distractor task was employed, at the 20- second retention time the nonretarded subjects performed significantly higher than the retarded subjects at both the 0- and 10- second retention times. This data adds support to the hypothesis that subjects with mental retardation tend to allow information to decay, or become lost, or interfered with even at relatively short retention intervals compared to nonretarded subjects.

Conclusion

The conclusions to be drawm from an analysis of the above data reveals a picture of retarded subjects as being quantitatively less capable of processing all three types of stimuli in this experiment when compared to nonretarded subjects under conditions of restricted cognitive strategy use. The retarded subjects demonstrated less efficient informtion processing, faster than normal stimulus decay, and greater stimulus interference on both recall and recognition items. This was evidenced by the fact that the retarded subjects' performance was significantly diminished by a difference in both exposure times and retention times as compared to the nonretarded subjects' performance on all three stimulus conditions.

Remarkably, however, both groups of subjects seemed to process the information in a relatively similar fashion on all variables measured. Both groups processed unfamilar designs more efficiently than nouns and consonants; both groups performed at higher levels of accuracy when given more exposure time to the various stimuli; and both groups of subjects performed at higher levels of accuracy under conditions of shorter periods of an intervening distractor task. Again, this must be considered within the context that on all dependent measures nonretarded subjects performed at significantly higher levels of recall and recognition short-term memory than the retarded subjects.

The results of the present study add strength to the structural defect argument for deficits of short-term memory in subjects with mental retardation. When retarded and nonretarded subjects are "theoretically equated" on the variable of voluntary cognitive strategy use

the nonretarded subjects perform significantly better than the retarded subjects on all dependent measures. These findings are consistent with those of Caruso and Detterman (1983); Clark and Detterman (1981); Cohen and Sandberg (1977); Ellis, Deacon, and Wooldridge (1985); Ellis and Meador (1985); Fagan (1984); Ferretti (1982); and Succuzzo and Michale (1984). All of these investigators reported short-term memory deficits for retarded subjects under like conditions and with similar tasks--indicating some sort of information processing deficit unexplainable by means of cognitive strategies. As Ellis, Deacon, and Wooldridge (1985, p. 401) stated, "To deny that there are structurally determined differences between the mental processes of retarded and nonretarded persons is tantamount to asserting that there are no limitations on retarded individuals' development of mental abilities other then those applicable to nonretarded persons. This, of course begs the question: Why are retarded persons retarded?"

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Table 1

F- Table Of Results

Source of Variance	df	SS	F	P-Values
Conditions A, B, C	2	219.065	240.49	0.0001
Subject Type	1	519.426	1140.45	0.0001
Exposure Times	1	35.930	78.89	0.0001
Retention Times	3	402.944	294.90	0.0001
Conditions A,B,C X Subject Type	2	10.512	11.54	0.0001
Conditions A,B,C, X Exposure Times	2	4.671	5.13	0.0061
Subject Type A,B,C, X Retention Times	6	24.0600	8.80	0.0001
Subject Type X Exposure Times	1	2.2978	5.05	0.0249
Subject Type X Retention Times	3	20.300	14.86	0.0001
Exposure Times X Retention Times	3	2.910	2.13	0.0947
Conditions A,B,C, X Subject Type X Exposure Times	2	1.472	1.62	0.1991
Conditions A,B,C X Subject Type X Retention Times	6	5.322	1.95	0.0703